PATENT APPLICATION TRANSMITTAL LETTER (Large Entity)	Docket No. INTL-0252-US (P7381)

TO THE ASSISTANT COMMISSIONER FOR PATENTS

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Christopher J. Lord, Karl O. Lillevold and Gim L. Deisher

For: NOISY EDGE REMOVAL FOR VIDEO TRANSMISSION

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Dated: 11/24/99

Signature

Timothy N. Trop, Reg. No. 28,994
Trop, Pruner, Hu & Miles, P.C.
8554 Katy Freeway, Suite 100
Houston, TX 77024
(713) 468-8880 [Ph]
(713) 468-8883 [Fax]

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P01LARGE/REV06

APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: NOISY EDGE REMOVAL FOR VIDEO TRANSMISSION

INVENTORS: CHRISTOPHER J. LORD, KARL O. LILLEVOLD and GIM L. DEISHER

Express Mail No.: EL515089056US

Date: November 24, 1999

NOISY EDGE REMOVAL FOR VIDEO TRANSMISSION

Background

This invention relates to digital video technology and, more particularly, to video encoding.

Digital video is formed from a sequence of images produced by a video camera. The individual images are called video frames. To produce the illusion of motion, video frames are transmitted at 20 frames per second or higher, such that the human eye does not isolate individual frames. The eye then perceives the video images as a continuous video stream.

Transmitting video may use more bandwidth than transmitting audio. A throughput of 75 Mbits per second is common for digital video while an audio transmission might occur at only 75 Kbits per second. A 56K baud modem transmits up to 56K bits per second. Thus, before transmitting digital video from computer to computer, an encoding scheme is typically employed.

A number of digital video encoding standards are used today. For example, some may use temporal redundancy to encode video. Temporal redundancy is the repetition observed between consecutive video frames. Using temporal redundancy, the changes from one frame to another may be stored instead of storing each entire frame before transmission.

Many personal computer-based digital video capture systems produce noisy lines along the edges of video frames. For example, the noise may result from improper handling of closed captioning signals. Alternatively, limitations in the associated hardware devices or software drivers may produce such noise.

Before being transmitted across a telephone line or other media, the video frames are typically compressed or encoded. Like all the other pixels of the video frame, the noisy pixels are encoded. The noisy edge pixels may be difficult

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to encode. The noisy pixels are often random and vary significantly from frame to frame. The temporal redundancy is thus reduced, so more bits may be used to encode the noisy frames than frames without the noise. Further, when a video image is subdivided during the encoding process, the noisy lines along the

5   edges of video frames may result in spurious frequency transform coefficients which are encoded along with the image. After decompression of the encoded noise, particularly at low bit rates, severe ringing artifacts may be visible along the noisy edges of the displayed video frame.

Thus, there is a continuing need for a mechanism for encoding video

10   frames that have noise.

Summary

In accordance with one embodiment of the invention, a method includes receiving a video frame, identifying noise in a first portion of the video frame, and replacing the first portion with a second portion of the video frame.

15   Advantages and other features of the invention will become apparent from the following description, the drawings, and the claims.

Brief Description of the Drawings

Figure 1 is a block diagram of the noisy edge removal mechanism according to one embodiment of the invention;

20   Figure 2a is a diagram of a top edge of a video frame according to one embodiment of the invention;

Figure 2b is a diagram of a left edge of a video frame according to one embodiment of the invention;

Figure 2c a diagram of a bottom edge of a video frame according to one

25   embodiment of the invention;

Figure 2d a diagram of a right edge of a video frame according to one embodiment of the invention;

Figure 3 is a diagram of a video frame divided into units according to one embodiment of the invention;

Figure 4 is a flow diagram of calculations performed during noisy edge detection according to one embodiment of the invention;

5 Figure 5 is a flow diagram of noisy edge analysis and filtration according to one embodiment of the invention;

Figure 6 is a flow diagram of the noisy edge removal mechanism according to one embodiment of the invention; and

Figure 7 is a block diagram of a system using the noisy edge removal

10 mechanism according to one embodiment of the invention.

Detailed Description

In accordance with one embodiment of the invention, noisy edges in video frames may be removed to achieve higher frame rates and better quality video. The noisy edge removal mechanism may be used with applications which employ

15 digital video encoding of captured content. Examples include video conferencing, video phone, network streaming video, and others.

By detecting the presence of noisy edges in a video frame, a noisy line may be removed and replaced by a clean neighboring line prior to encoding. Noise may be removed from the top edge, either side edge, or the bottom edge

20 of the video frame 10 as needed.

Turning to Figure 1, a noisy edge removal mechanism 20 may filter noise from a video frame 10 prior to entering a video encoder 18. In one embodiment of the invention, the noisy edge removal mechanism 20 includes a noisy edge detector 14 and a noisy edge filter 16.

25 Initially, the noisy edge detector 14 receives a frame 10. The frame 10 is one of a plurality of frames 10 which make up a stream of video. The noisy

edge removal mechanism 20 may be invoked for each frame 10 of the video stream, one at a time.

For each frame 10, the noisy edge detector 14 analyzes one or more edges of the video frame 10. In one embodiment of the invention, an edge of the video frame 10 is selected, then divided into four equally sized portions. In Figure 2a, the top edge of the video frame 10 is divided into portions 20a, 21a, 22a, and 23a. These portions may be rows of the video frame 10, for example.

In Figure 2b, the left edge of the video frame 10 is divided into portions 20b, 21b, 22b, and 23b. These portions may be columns of the video frame 10, for example. In Figure 2c, the bottom edge of the video frame 10 is divided into portions 20c, 21c, 22c, and 23c. In Figure 2d, the right edge of the video frame is divided into portions 20d, 21d, 22d, and 23d.

Once the edge of the video frame 10 is divided into portions of equal size, the portions are then subdivided into units of equal size. In Figure 3, a part of the video frame 10 of Figure 2a is subdivided into a plurality of units 24. Portion 20a includes units 24a, 24b, 24c, 24d, 24e, and 24f. Portion 21a includes units 24g, 24h, 24i, 24j, 24k, and 24l. Portion 22a includes units 24m, 24n, 24o, 24p, 24q, and 24r. Portion 23a includes units 24s, 24t, 24u, 24v, 24w, and 24x.

Each unit 24 of the video frame 10 is associated with a value. For example, a video display may be subdivided into pixels. Each pixel commonly has a value associated with the pixel, which may be stored in video memory. Each unit 24 of Figure 3 may likewise be associated with a distinct value.

In one embodiment of the invention, the noisy edge detector 14 determines the presence of noise based, in part, on comparisons between the values of the units 24 of the video frame 10. If adjacent units 24 are not similar, for example, noise may sometimes be inferred. So, once the video frame 10 is divided into discrete units 24, each one of which is assigned a value, mathematical operations may be performed to analyze the video frame 10.

Comparisons between values of the units 24 may be made using mathematical operations. In one embodiment, the values of the units 24 in one portion are compared to the values of the units 24 in a second, adjacent portion. The results of these comparisons are added together, to arrive at a result which

5   is representative of the relationship between the two portions. A second pair of portions is likewise analyzed, supplying a second result, and so on. These results are then compared, and analyzed against one or more threshold values. In one embodiment of the invention, the threshold values may be adaptable to the type of noise or other criteria.

10   In Figure 4, an analysis of the video frame 10, according to one embodiment of the invention, commences with the selection of an edge of the video frame (top, right, left, or bottom), subdivision of the video frame 10 into portions of equal size, and further subdivision in to units 24 (block 70). Although the following examples describe dividing an edge of the video frame 10

15   into four portions, the analysis hereinafter described may be performed on a larger or smaller number of portions, as desired.

A value is associated with each unit 24. The value may be an 8-bit binary value, a 16-bit binary value, or other value. The values are used to compare each unit 24 with another unit 24 in order to detect the presence of noise in the

20   video frame 10.

Once the edge of the video frame 10 has been subdivided into units 24, a pair of threshold values, T1 and T2, may be calculated (block 72). The threshold values are used to determine whether a value associated with one portion 20, 21, 22 or 23 of the video frame 10 varies significantly from a value associated

25   with a second portion 20, 21, 22, or 23 of the video frame 10.

In one embodiment of the invention, these threshold values are based upon two variables, α and β. The values for α and β may be determined by analyzing one or more video frames 10 in which noise is known to be present.

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The values for α and β may also be based upon the source of the noise. For example, noise which results from the improper handling of closed captioning signals may produce a certain, predictable type of noise, to which a particular α value may be assigned. Alternatively, certain types of video capture devices may produce noise along the edges of the video frame, and thus a particular α or β variable may be appropriate. The α variable is presumed larger than the β variable, so that both a "stronger" (or larger) threshold value and a "weaker" (or smaller) threshold value may be used to analyze the edge of the video frame 10.

In one embodiment of the invention, once the α and β variables are known, T1 and T2 may be calculated based upon the following formulas:

$$T_1 = (\# \text{ units/portion}) \times \alpha$$

$$T_2 = (\# \text{ units/portion}) \times \beta$$

where α > β. Because α > β, the threshold value T1 is greater than the threshold value T2.

In addition to being created based upon the type of noise and other criteria, the α and β variables, and thus the threshold values, T1 and T2, may be changed during the analysis of the input video signal. For example, following analysis of the first few video frames 10 of a video signal, the α and β variables may be adjusted, if desired.

Looking back at Figure 4, a comparison of units 24 along an edge of the video frame 10 is performed (block 74). The comparison may be performed in a number of ways. In one embodiment of the invention, all units 24 of one portion are subtracted from all units 24 of an adjacent portion, to arrive at a plurality of results, the absolute values of which are then added together. This is called the sum of absolute differences, or SAD.

For example, looking back at Figure 3, the sum of absolute differences between portions 20a and 21a is:

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$$SAD_{20a21a} = |(24a - 24g) + (24b - 24h) + (24c - 24i) + (24d - 24j) + (24e - 24k) + (24f - 24l) + \ldots|$$

where "24a" means "the value of unit 24a," etc. The sum of absolute differences between portions 21a and 22a is:

$$SAD_{21a22a} = |(24g - 24m) + (24h - 24n) + (24i - 24o) + (24j - 24p) + (24k - 24q) + (24l - 24r) + \ldots|$$

and the sum of absolute differences between portions 22a and 23a is:

$$SAD_{22a23a} = |(24m - 24s) + (24n - 24t) + (24o - 24u) + (24p - 24v) + (24q - 24w) + (24r - 24x) + \ldots|$$

Following these calculations, three values, SAD_{20a21a}, SAD_{21a22a}, and SAD_{22a23a} result. These SAD values provide a discrete measure for analysis of the portions 20 through 23 of the video frame 10, not just the units 24 contained therein.

Although the units 24 for four portions are compared to arrive at three SAD results, comparison of five portions to arrive at four SAD results, comparison of six portion to arrive at five SAD results, and so on, may be made. Alternatively, two portions may be compared to arrive at a single SAD result or three portions may be compared to arrive at two SAD results.

Turning back to Figure 4, once the SAD values for the portions 20 through 23 are determined, these values may be analyzed as well (block 76). In one embodiment of the invention, the "adjacent" SAD values are subtracted from one another, to arrive at one or more difference values, Dn.

For example, in the video frame 10 of Figure 3, because there are three SAD values, two difference values, D_1 and D_2, may be calculated as follows:

$$D_1 = |SAD_{20a21a} - SAD_{21a22a}|$$
$$D_2 = |SAD_{21a22a} - SAD_{22a23a}|$$

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The difference value, D_1, results from calculations related to portions of the video frame 10 which are relatively closer to the edge of the video frame 10, such as portions 20a, 21a, and 22a. The difference value, D_2, results from calculations of portions related to the video frame 10 which are relatively further from the edge of the video frame 10, such as portions 21a, 22a, and 23a. Where more than three SAD values are calculated, more difference values may likewise be calculated, as needed.

In one embodiment of the invention, once the difference values, D_1 and D_2, are calculated, they may then be analyzed against the threshold values, T_1 and T_2. Recall that the threshold value T_1 is calculated based upon the variable α while the threshold value T_2 is calculated based upon the variable β. In one embodiment of the invention, α is greater than β. Accordingly, T_1 is greater than T_2 in value. Thus, a difference value which is larger than T_1 is presumed to be more likely to have noise than a difference value which is larger than T_2.

In one embodiment of the invention, the presence of noise in a previous video frame 10 is relevant to the analysis of one or more subsequent frames. Recall from Figure 1 that the noisy edge detection mechanism 20 receives each video frame 10 of the input video signal, one after another. Thus, the result of the analysis of a prior frame may be used in the analysis of subsequent frames.

A Boolean variable, NOISEFOUND, may be used to keep track of noise found in a previous frame. The variable may then be used during analysis of a subsequent frame. Although the variable NOISEFOUND provides information about the detection of noise from a single prior frame, multiple variables may alternatively be included in the analysis of multiple subsequent frames, as desired.

In accordance with one embodiment of the present invention, the analysis includes four comparisons between the values, D_1, D_2, T_1, and T_2, as shown in Figure 5. In one comparison, if D_2 is greater than T_1, because T_1 is the larger

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threshold value, noise is presumed to be found (diamond 82). Accordingly, two outermost portions, portion 20 and portion 21 of the video frame 10 are replaced with a third portion, portion 22, which is closer in from the edge of the video frame 10 (block 90).

For example, in Figure 2c, portions 20c and 21c is replaced with portion 22c. The edge of the video frame 10 then includes, from the outside in, portions 20c, 20c, 20c, and 23c (the fourth portion, 23c, is not replaced).

Next, D_2 is compared to T_2 (diamond 84). If D_2 is larger than T_2, then D_2 is in between the two threshold values, T_1 and T_2. If, D_2 is between the two threshold values, and noise was found in the previous frame (as denoted by NOISEFOUND being TRUE), noise is presumed to be found (diamond 84). The two outermost portions, portion 20 and portion 21, of the video frame 10 are replaced with a third portion, portion 22, which is closer in from the edge of the video frame 10 (block 90).

Next, the difference value D_1 is compared to the threshold values. If D_1 is larger than T_1 (diamond 86), a first portion 20 of the video frame 10 is replaced with a second portion 21 which is farther from the edge (block 92). For example, in Figure 2d, portion 20d is replaced with portion 21d. The edge of the video frame 10 then includes, from the outside in, portions 21d, 21d, 22d, and 23d.

The difference value D_1 is then compared to the second threshold value T_2 (diamond 86). If D_1 is in between the two threshold values and noise was found in the previous frame, a first portion 20 of the video frame 10 is replaced with a second portion 21 which is farther from the edge (block 92). If D_1 is smaller than both threshold values, T_1 and T_2, then no noise is presumed, and no action is taken (block 94).

Recall that D_1 relates to portions 20 through 22 of the video frame 10 which are relatively closer to the edge, while D_2 relates to portions 21 through

23 of the video frame which are relatively farther from the edge. Accordingly, in the analysis of D_1, the replacement of a single portion 20 with a second portion 21, occurs (block 92), while, in the analysis of D_2, the replacement of two portions, portions 20 and 21, with a third portion, portion 22, occurs (block 90).

5   The above calculations identify noise by observing the spatial correlation between the portions 20 through 23 along the edge of the video frame 10. In other words, how similar portions 20 through 23 are to one another help to identify noise in the video frame 10. In addition to the calculations, noise detection in the previous frame may be included in analyzing the current frame.

10   Once the noisy edge detector 14 has completed the analysis, the noisy edge filter 16 may replace one or more portions of the video frame 10 with a clean neighboring portion, in one embodiment of the invention. A new video frame 11 may then enter the video encoder 18.

     A software program, for implementing one embodiment of the invention, shown in Figure 6, begins by clearing the Boolean variable, NOISEFOUND (block 102). NOISEFOUND indicates whether the previous frame required noise removal. An integer variable, FRAME, is also cleared to zero. FRAME keeps track of the current frame. FRAME is incremented (block 104).

     For the current video frame received, the sum of absolute differences for the first four portions 20 through 23 of the video frame 10 is calculated (block 106). These calculations result in three values, SAD_{2021}, SAD_{2122}, and SAD_{2223}. Although four portions of the video frame 10 are analyzed in the example, this number may be adjusted to a larger or smaller number, as desired.

     From the SAD values, two difference values, D_1, and D_2, are calculated. D_1 is the absolute value of the difference between SAD_{2021} and SAD_{2122}. Likewise, the second difference value, D_2, represents the difference between SAD_{2122} and SAD_{2223}. The threshold values, T_1 and T_2, are calculated (block

110). Once the calculations D_1, D_2, T_1, and T_2 are completed, analysis of the video frame 10 for noise may begin.

In one embodiment of the invention, a series of queries determines whether the difference values D_1 and D_2 exceed the threshold values T_1 and T_2 (diamond 112). If the second difference value, D_2, is greater than the first threshold value, T_1, then noise has been detected. Accordingly, portions one and two of the video frame 10 are replaced with portion three (block 120). Further, the variable NOISEFOUND is set to TRUE (block 122), indicating that noise was found on the current frame. During analysis of subsequent frames, the variable NOISEFOUND is again tested.

Next, if the second difference value, D_2, exceeds the second threshold value, T_2, and the variable NOISEFOUND is TRUE, then noise has again been detected (diamond 114). Again, portions one and two are replaced with portions three of the video frame 10 (block 120).

Where the first two calculations fail to result in noise detection, a second pair of inquiries may be initiated. The first difference value, D_1, is compared to the first threshold value, T_1 (diamond 116). If D_1 is larger, noise has been detected. In contrast to the result in block 120, however, only portion one is replaced with portion two (block 124). Otherwise, D_1 may be compared with the second threshold value, T_2. If D_1 is greater than T_2 and the variable NOISEFOUND is TRUE, then noise is detected (diamond 118). Again, portion one is replaced with portion two (block 124). The variable NOISEFOUND is set to TRUE (block 122). Otherwise, the variable NOISEFOUND is set to FALSE (block 126).

Following updates of the variable NOISEFOUND (block 122 and 126), the noisy edge removal mechanism 20 inquires whether the last frame has been reached (diamond 128). If so, the operation is complete (block 130).

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Otherwise, the variable FRAME is incremented and the process is repeated (block 104).

In Figure 7, in accordance with one embodiment of the invention, a processor-based system 70 may include a processor 30 coupled to an accelerated graphics port (AGP) chipset 52. The Accelerated Graphic Port Specification, Rev. 2.0 is available from Intel Corporation of Santa Clara, California. The AGP chipset 52 is coupled to a display 58 and a system memory 34. The AGP chipset 52 is further coupled to a bus 38, for coupling to other circuitry of the processor-based system 70.

A bridge 36 coupled between the bus 38 and a secondary bus 40 is coupled to a hard disk drive 44. The noisy edge removal mechanism 20 and the video encoding software 18 may be stored on the hard disk drive 44. A multi-function, super I/O, or SIO, chip 42, coupled to the secondary bus 40, may support several devices in the processor-based system 70, including a floppy disk drive 46, a keyboard 48, a mouse 50 and a modem 64. Also coupled to the secondary bus 40 is a video capture device 60. A video input signal 62 may enter the system 70 from the video capture device 60.

The noisy edge removal mechanism 20 may be stored on the hard disk drive 44 such that, upon receiving the video input signal 62, the noisy edge removal program 20 is loaded into the memory 34 and executed. The video encoder 18, also stored on the hard disk drive 44 in one embodiment of the invention, may be used to encode the resulting frames.

In some embodiments of the invention, a noisy edge removal mechanism may remove noisy edges from a video frame prior to transmission. Where noisy edges are removed from a digital image, temporal prediction between frames of the digital image may result. In a digital image where temporal prediction improves, fewer bits may be used to encode the digital image. Where noisy lines are removed from a digital image, spurious frequency transform coefficients

may be reduced. Where fewer bits are used to encode a digital image, a faster frame rate may result or the video quality may improve.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is:

1   1.   A method comprising:

2   receiving a video frame;

3   identifying noise in a first portion of the video frame; and

4   replacing the first portion with a second portion of the video frame.

1   2.   The method of claim 1, wherein identifying further comprises:

2   associating a noise level with the first portion of the video frame;

3   and

4   comparing the noise level to a predetermined value.

1   3.   The method of claim 2, wherein associating further

2   comprises distinguishing the first portion from the second portion.

1   4.   The method of claim 3, wherein distinguishing further

2   comprises:

3   associating a first value with the first portion;

4   associating a second value with the second portion; and

5   performing a plurality of arithmetic operations between the

6   first value and the second value.

1   5.   The method of claim 4, wherein associating a first value with the

2   first portion further comprises:

3   identifying a plurality of values associated with the first portion;

4   and

5   performing an arithmetic operation on the plurality of values to

6   render the first value.

1　　6.　　The method of claim 2, wherein comparing the noise to a

2　predetermined value comprises comparing the noise to a noise level found in a

3　second video frame.

1　　7.　　The method of claim 2, wherein comparing the noise to a

2　predetermined value comprises associating the predetermined value to the type

3　of video input signal.

1　　8.　　The method of claim 2, wherein comparing the noise to a

2　predetermined value comprise associating the predetermined value to the type of

3　noise in the video frame.

1　　9.　　A system including:

2　　　　a bus;

3　　　　a processor coupled to the bus;

4　　　　a device coupled to the bus to receive a video signal; and

5　　　　a storage medium coupled to the bus including a software program

6　that, upon execution:

7　　　　　　detects noise in a first portion of a video frame of the video

8　　　　　　signal; and

9　　　　　　replaces a first portion of the video frame.

1　　10.　　The system of claim 9, wherein the video frame is stored in a

2　memory and, upon execution, the software program writes to the memory to

3　replace the first portion of the video frame.

1   11.   The system of claim 10, wherein, upon execution, the software
2   program further detects noise by comparing a noise level associated with the
3   first portion of the video frame with a predetermined value.

1   12.   The system of claim 11, wherein the predetermined value is stored
2   in the memory.

1   13.   The system of claim 12, wherein the predetermined value is related
2   to a noise level found in a second video frame.

1   14.   The system of claim 10, wherein the predetermined value is
2   related to the type of video signal.

1   15.   The system of claim 9, wherein the storage medium is a hard disk
2   drive.

1   16.   An article comprising a medium storing instructions that cause a
2   processor-based system to:
3   locate a video frame of a video signal;
4   identify noise in a first portion of the video frame; and
5   replace the first portion with a second portion of the video frame.

1   17.   The article of claim 16, further storing instructions that cause the
2   processor-based system to locate the video frame by reading a memory device.

1   18.   The article of claim 17, further storing instructions that cause the
2   processor-based system to:
3   associate a noise level with the first portion of the video frame; and

4   compare the noise level to a predetermined value.

1   19.   The article of claim 18, further storing instructions that cause the

2   processor-based system to:

3   associate a first value with the first portion;

4   associate a second value with the second portion; and

5   perform a plurality of arithmetic operations between the first value

6   and the second value.

1   20.   The article of claim 19, further storing instructions that cause the

2   processor-based system to:

3   identify a plurality of values associated with the first portion; and

4   perform an arithmetic operation on the plurality of values to render

5   the first value.

1   21.   The article of claim 18, further storing instructions that cause the

2   processor-based system to compare the noise level to a predetermined value by

3   associating the predetermined value with a noise level found in a second video

4   frame.

5   22.   The article of claim 16, wherein the medium storing instructions is

6   a memory device.

1   23.   The article of claim 18, further storing instructions that cause the

2   processor-based system to compare the noise level to a predetermined value by

3   associating the predetermined value to the type of video signal.

1   24.   The article of claim 18, further storing instructions that cause the

2   processor-based system to compare the noise level to a predetermined value by

3   associating the predetermined value to the type of noise in the video frame.

NOISY EDGE REMOVAL FOR VIDEO TRANSMISSION

Abstract of the Disclosure

A method for removing noise from a video input, prior to encoding includes receiving a frame of a video signal, identifying noise within the frame, and eliminating the noise from the frame. The video frame may then be
5   encoded.
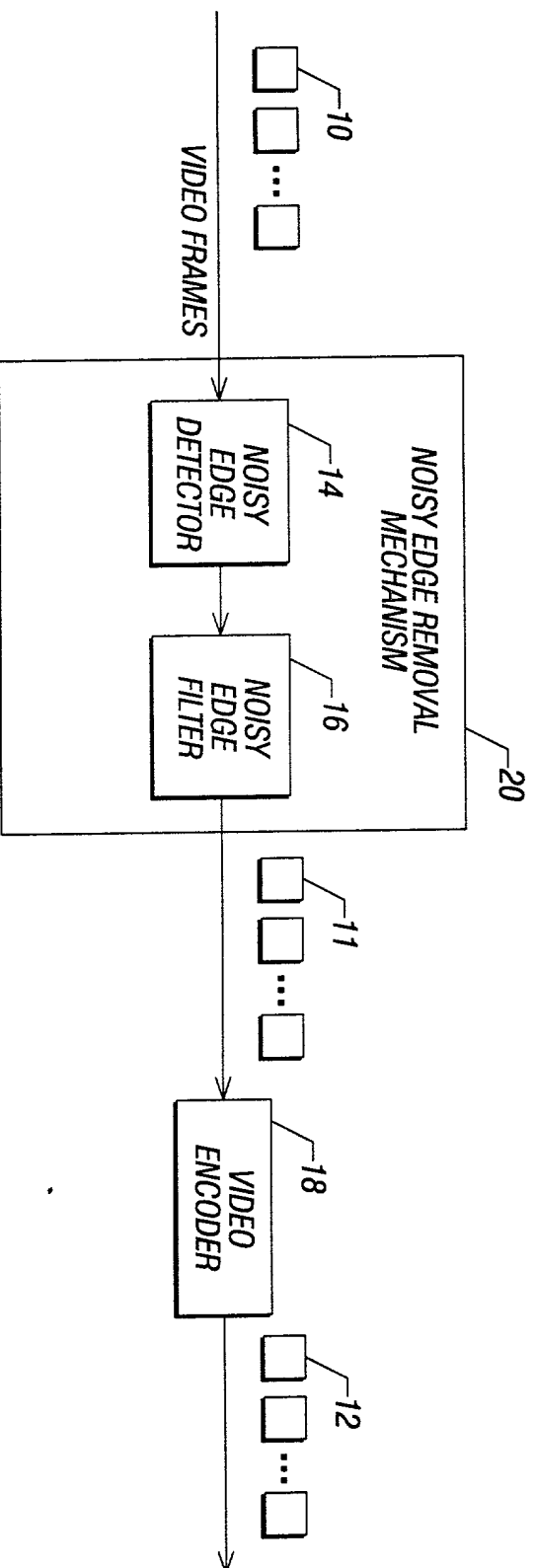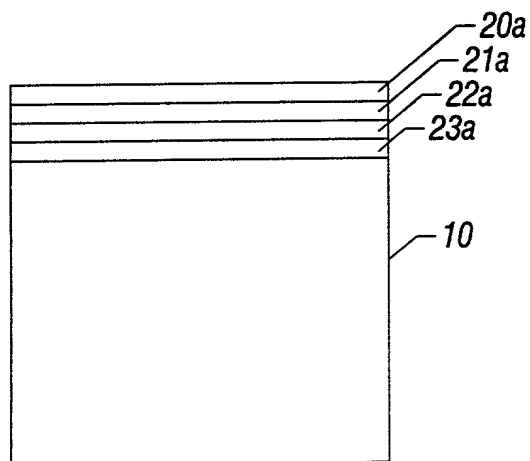
FIGURE 1

VIDEO FRAME

FIGURE 2a
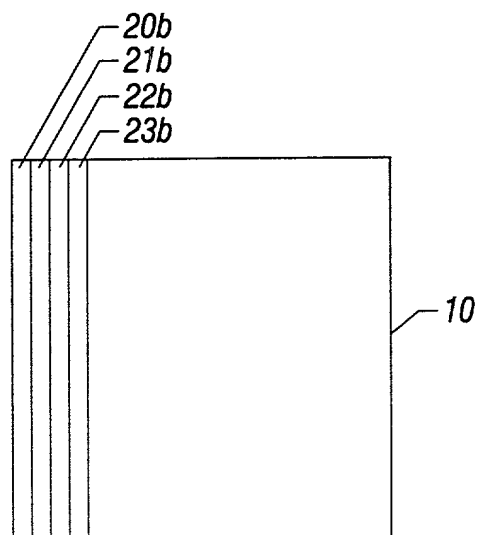
VIDEO FRAME

FIGURE 2b
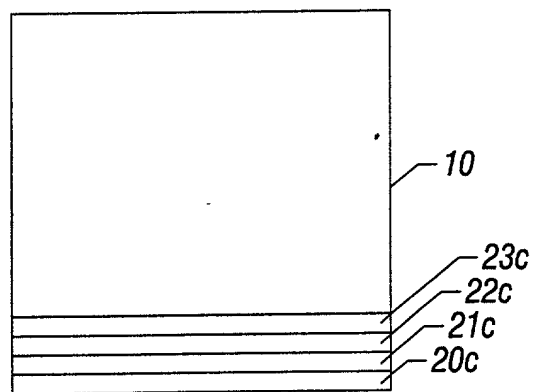
VIDEO FRAME

FIGURE 2c
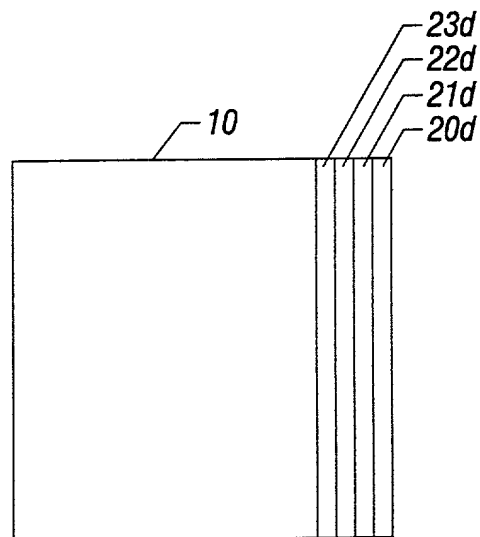
VIDEO FRAME

FIGURE 2d

24a	24b	24c	24d	24e	24f	• • •
24g	24h	24i	24j	24k	24l	• • •
24m	24n	24o	24p	24q	24r	• • •
24s	24t	24u	24v	24w	24x	• • •

10

20a

21a

22a

23a

FIGURE 3

BEGIN ─68

DIVIDE FRAME INTO PORTIONS
AND UNITS SUCH THAT EACH UNIT HAS
A VALUE ASSOCIATED WITH IT ─70

CALCULATE THRESHOLD VALUES
BASED ON NUMBER UNITS/PORTION ─72

CALCULATE SAD VALUES
BETWEEN EACH PORTION ─74

CALCULATE DIFFERENCE
OF SAD VALUES ─76
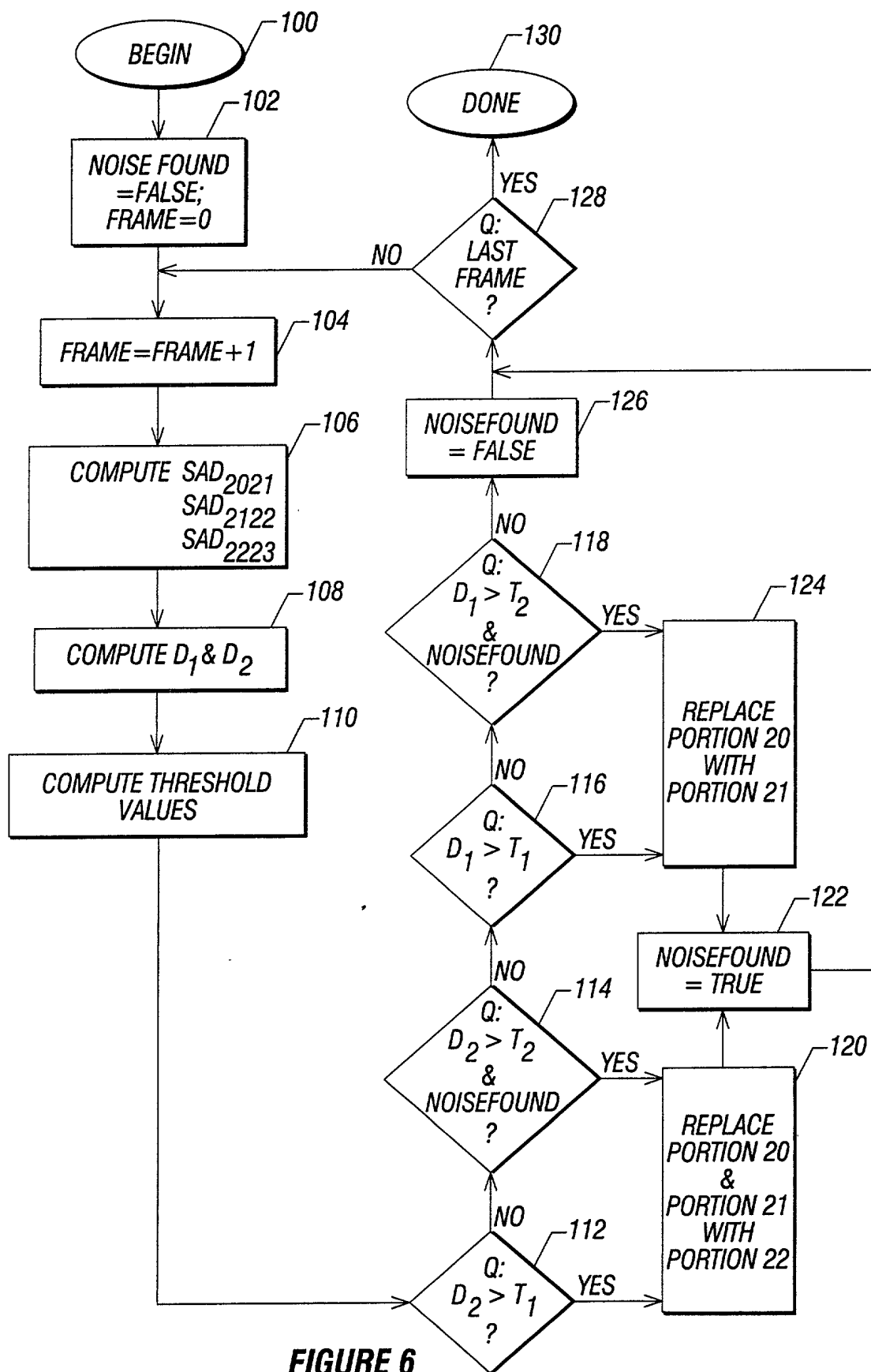
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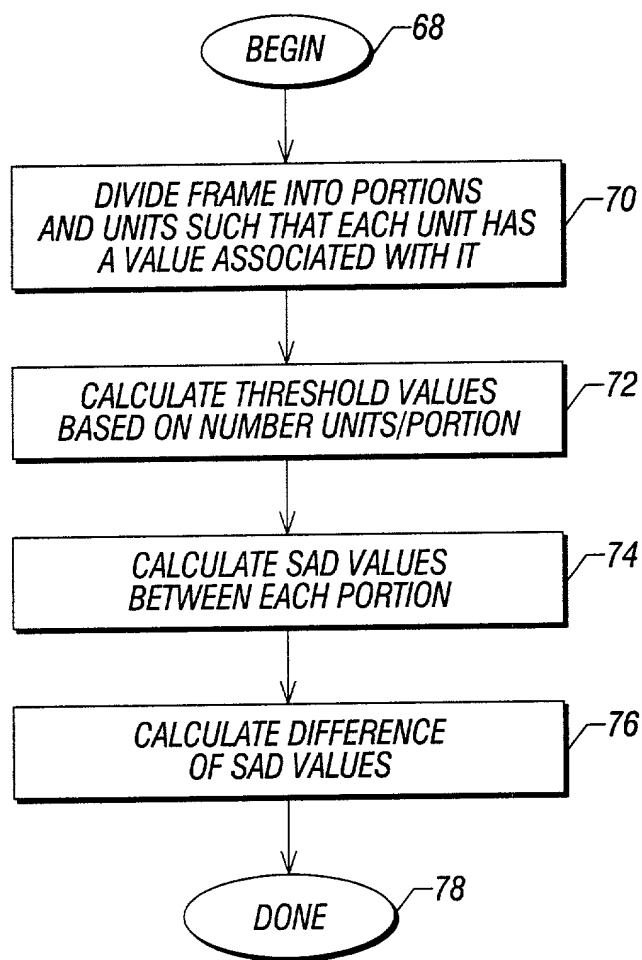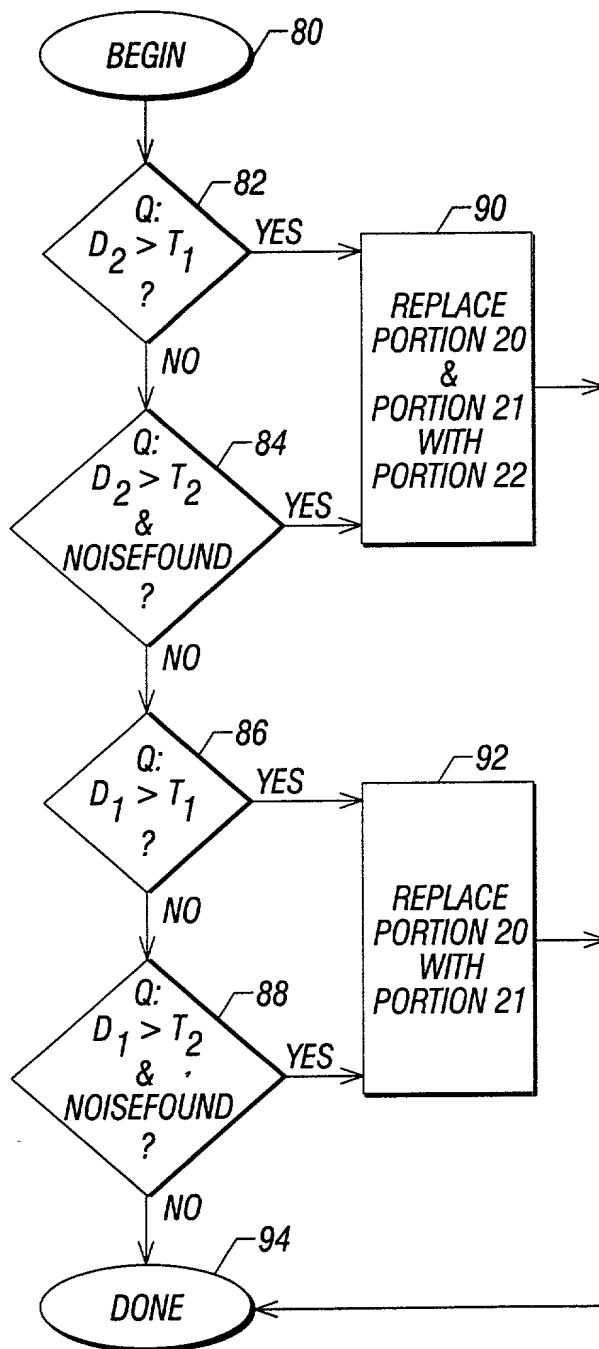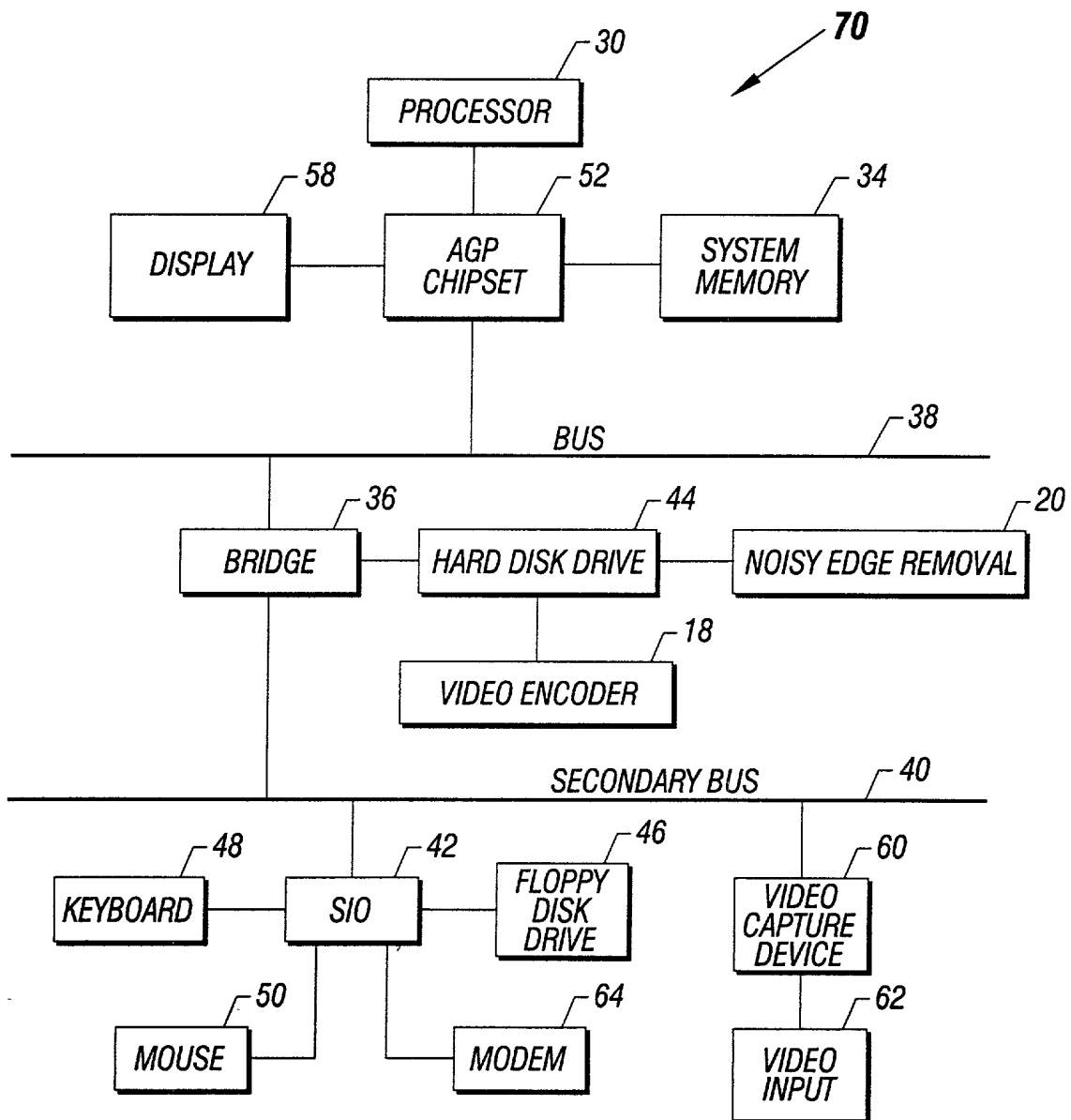
FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

<u>DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION</u>

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

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the specification of which

| X | is attached hereto. |

was filed on _____ as
    United States Application Number _____
    or PCT International Application Number _____
    and was amended on _____
                                   (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate Issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

<u>Prior Foreign Application(s):</u>   <u>Priority Claimed</u>

Number	(Country)	(Day/Month/Year Filed)	Yes	No
Number	(Country)	(Day/Month/Year Filed)	Yes	No
Number	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of the United States provisional application(s) listed below:

(Application Number)	(Filing Date)

(Application Number)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:
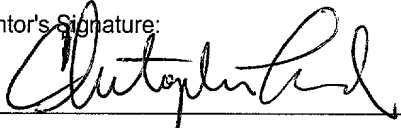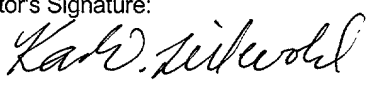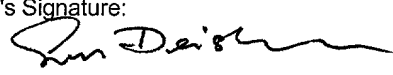
(Application Number)	Filing Date	(Status-patented, pending, abandoned)

(Application Number)	Filing Date	(Status-patented, pending, abandoned)

I hereby appoint Timothy N. Trop, Reg. No. 28,994; Fred G. Pruner, Jr., Reg. No. 40,779, Dan C. Hu, Reg. No. 40,025; Coe F. Miles, Reg. No. 38,559, and John R. Merkling, Reg. No. 31,716 my patent attorneys, of TROP, PRUNER, HU & MILES, P.C., with offices located at 8554 Katy Freeway, Ste. 100, Houston, TX 77024, telephone (713) 468-8880, and Joseph R. Bond, Reg. No. 36,458; Richard C. Calderwood, Reg. No. 35,468; Sean Fitzgerald, Reg. No. 32,027; David J. Kaplan, Reg. No. 41,105; Leo V. Novakoski, Reg. No. 37,198; Naomi Obinata, Reg. No. 39,320; Thomas C. Reynolds, Reg. No. 32,488; Steven P. Skabrat, Reg. No. 36,279; Howard A. Skaist, Reg. No. 36,008; Steven C. Stewart, Reg. No. 33,555; Raymond J. Werner, Reg. No. 34,752; and Charles K. Young, Reg. No. 39,425; my patent attorneys, of INTEL CORPORATION; with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to <u>Timothy N. Trop</u>, TROP, PRUNER, HU & MILES, P.C., 8554 Katy Freeway, Ste. 100, Houston, TX 77024 and direct telephone calls to <u>Timothy N. Trop,</u> (713) 468-8880.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor: **CHRISTOPHER J. LORD**	
Inventor's Signature:	Date: *Nov. 12, 1999*
Residence: **PORTLAND, OREGON**	Citizenship: **U.S.**
Post Office Address: **9170 NW STARK COURT, PORTLAND, OREGON 97229**	
Full Name of Second/Joint Inventor: **KARL O. LILLEVOLD**	
Inventor's Signature:	Date: *Nov. 21, 1999*
Residence: **SEATTLE, WASHINGTON**	Citizenship: **NORWAY**
Post Office Address: **2922 WESTERN AVENUE, SEATTLE, WASHINGTON 98121**	
Full Name of Third/Joint Inventor: **GIM L. DEISHER**	
Inventor's Signature:	Date: *Nov. 12, 99*
Residence: **HILLSBORO, OREGON**	Citizenship: **MALAYSIA**
Post Office Address: **2665 NE ANNA AVENUE, HILLSBORO, OREGON 97124**	

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